

# Analysis of customer's satisfaction in public transport using fuzzy logic for Bhopal City

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**Abstract**— Satisfaction of customers is one of the most valuable parameters to be considered in any services since customer retention is directly dependent on it. The quality of service is not given importance by the service providers in Bhopal city due to the high demand as compared with the supply. However, the attributes considered important by the commuters have to be identified for improving the quality of service in terms of their satisfaction level. This paper focuses on the commuter's satisfaction with the public transit system in the Bhopal city. A questionnaire was developed for the commuter's opinion in the buses to explore the satisfaction level of the users. Low floor Bus users were found to be the most satisfied in comparison to minibus users. However, the overall average of satisfaction reflects that generally all users are not sufficiently satisfied with the existing transit system. This research work develops a framework which uses fuzzy set theory in order to calculate customer satisfaction, starting from a questionnaire based survey. The outcomes help the transit authorities and operators towards the attributes that scored low in satisfaction and which require improvements.

**Index Terms**— Customer satisfaction, public transit service, satisfaction level.

## I. INTRODUCTION

General customer satisfaction studies link the use or reuse of a commodity or service to the extent to which customers are satisfied. High quality of service is correlated with relatively high customer satisfaction [5]. In the developed countries, where the demand for public transport is low, the service authorities try to attract passengers' attention by providing maximum possible level-of-service (LOS). Attributes like air conditioning, high levels of comfort, safety and reliability, etc., are being weighted highly by the users. However, the situation is completely different in a developing country, like, India [20]. In Indian cities the demand of public transit is very high due to the low ownership of personalized vehicle ownership. As the personalized vehicle ownership is quite low, a large number of resident are captive users of public transport, except in a few metro cities. The people with lower income compromise with comfort for cheaper ride but the people with moderate or high income and vehicle owning group will look for comfort factors and good Level of service. This research investigated the extent of customer satisfaction

for users of public transit services in Bhopal City. Public transport users have needs and preferences, including reliability, convenience, safety, comfort, accessibility, and affordability, that affect their satisfaction with the services provided. Factors that affect the choice of passengers are given in the table I

TABLE I  
SHOWING FACTORS THAT AFFECTS THE PASSENGER'S CHOICE

	Auto	Tata Magic	Mini Bus	Low Floor Bus
Cheap fare	6%	84%	86%	76%
Costly	35%	15%	13%	25%
Non	88%	16%	19%	15%
Availability				
Safe	67%	65%	83%	90%
Good Area	57%	56%	73%	83%
Coverage				
Bad Crew	66%	45%	51%	38%
Behaviour				
Unsafe	29%	27%	17%	9%
Easy	45%	63%	79%	77%
Availability				
Comfortable	58%	84%	76%	88%
Poor Area	2%	15%	17%	11%
Coverage				
Others	63%	79%	71%	66%

A comprehensive list of travel attributes influencing public transport-user satisfaction has been derived from the literature and investigated through user surveys. In order to determine the quality of a public transport system, user surveys are used to collect ratings on specific operational aspects, such as frequency, fare, seat availability, safety and many among others. The results and findings of this research highlight to transport planners and decision makers the attributes that are important for public transport users, by mode, to focus on. The outcomes draw the attention of transit authorities and operators towards the attributes that had a low score in satisfaction; thus these attributes require mandatory improvement. This research work uses the fuzzy sets, as an effective tool to process the qualitative information as fuzzy application is most suitable way to use linguistic assessments instead of numerical values.

Manuscript received December 23, 2014.

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II. OBJECTIVE

To develop a methodology to assess the service performance through triplet fuzzy numbers (TFNs) with fuzzy  $\alpha$ -cut of public transit services using commuter’s opinion. To develop a fuzzy- based decision support framework and apply the model for commuter’s satisfaction and the service provider to improve overall level of service.

III. LITERATURE REVIEW

Over the last two decades, service quality has been a subject of interest for many studies [6] [9]. It has also been increasingly receiving academic attention by management scholars, and has been prioritized in the management domain [7]. Parasuraman et al.[19] describes the quality of service as “the degree and direction of discrepancy between the consumer’s perceptions and expectations, or the extent to which a service meets or exceeds customer expectations.” By identifying differences between customer expectations and perceptions of service, management personnel would be able to remedy shortcomings in the products or services they offer. To relate this to public transport services, a transit user is viewed as a customer who needs to be satisfied with the quality of service; users of public transport services compare the provided transit services with their needs and expectations [19]. Satisfaction could be represented as a function of the performance of the attributes of the service, personal needs (and/or preferences) of the user, past experiences, and previous knowledge. During the last decades, efforts have been made to evaluate transport user satisfaction by assessing the quality of the service and identifying users’ priorities [8]. Fuzzy set theory has been introduced by Zadeh to deal with problems involving uncertainty and fuzziness [10]. Numerous studies have applied fuzzy set theory to research problems involving uncertainty. Chien et al. [9] have used fuzzy number to assess perceived service quality and clarify the strengths and weaknesses of Taiwanese retail stores [9]. Alreck et al. [11] in marketing research, most questionnaires use Likert scales to measure respondents' attitude, which is linguistic in nature. Instead of data being discrete, they have used statistical methods that accommodate continuous data [11]. Hung et al. [12] has clarified the evaluation of weapon systems using fuzzy arithmetic operations. In the above fuzzy based researches, the qualitative data or linguistic terms are used to represent imprecise assessments of decision criteria or performance attributes are all expressed using fuzzy number [12].

IV. METHODOLOGY OF FUZZY REASONING APPROACH

The proposed approach for service quality evaluation is fuzzy reasoning approach (FRA). Following steps involved in FRA as

- Selection of proper input and output attributes for survey in public transit.
- Determination of the of linguistic terms related with input and output attributes respectively
- Decide the most suitable membership function fuzzy operator reasoning mechanism and so on.
- Selection of suitable type of fuzzy inference system.
- Design a collection of fuzzy if then rule.

The triplets (0,0.5,1),(0.5,1,2),(1,2,3),(2.5,3.5,4) and (3.5,4.5,5) of Bi for i=1,2,3,...n in linguistic terms, mean “Very Poor”, “ Poor”, “Neutral”, “ Good” , “ Very Good ” respectively. Similarly the triplets triplets (0,0.5,1),(0.5,1,2),(1,2,3),(2.5,3.5,4) of Bi for i=1,2,3,...n represent “Very Important”, “Important”, “ Neutral”, “Slightly Important”, “Not Important”.

Table IV describes the relative weightage of attributes used in questionnaire survey. To clarify which attribute is weak or strong objectively, it is important to differentiate whether the discrepancy between satisfaction degree and importance degree is positive or negative. Instead of average difference scores, we apply the following procedure to justify which attribute is preferable.

Defuzzification

The procedure of defuzzification is to locate the best non fuzzy performance value. There are several methods available for defuzzification such as Mean of the maximum, Centre of area, and  $\alpha$ -cut method etc [17].

TABLE II  
MEMBERSHIP FUNCTIONS OF FUZZY SETS FOR RATINGS

Ratings	Fuzzy Set	Membership Function
Extremely Not Satisfied	EXNS	$0 \leq 0.3 \leq 1$
Not Satisfied	NS	$0.3 \leq 1 \leq 1.5$
Neutral	N	$1.5 \leq 2 \leq 3.5$
Satisfied	S	$2.5 \leq 3.5 \leq 4$
Extremely Satisfied	EX	$4 \leq 4.5 \leq 5$

TABLE III  
MEMBERSHIP FUNCTIONS OF FUZZY SET FOR WEIGHTS

Ratings	Fuzzy Set	Membership Function
Very Important	VI	$0 \leq 0.3 \leq 1$
Important	I	$0.3 \leq 1 \leq 1.5$
Neutral	N	$1.5 \leq 2 \leq 3.5$
Slightly Important	SI	$2.5 \leq 3.5 \leq 4$
Not Important	NI	$4 \leq 4.5 \leq 5$

TABLE IV  
ATTRIBUTES WEIGHTAGE

	Weightage on attributes by passengers in Low Floor Buses				
	5	4	3	2	1
Frequency	233	155	45	63	47
Fare	257	200	27	22	37
Safety	153	150	97	77	66
Seat	93	103	237	22	88
Availability					
Reliability	105	128	218	42	50
Staff	88	156	117	98	84
Behaviour					
Speed	100	179	103	87	74
Internal	57	207	111	64	104
Asthetic					
Entry & Exit	92	179	113	21	138

TABLE V  
 ATTRIBUTES WEIGHTAGE

	Weightage on attributes by passengers in Mini-Buses				
	5	4	3	2	1
Frequency	109	97	127	95	115
Fare	300	200	20	15	8
Safety	105	117	85	103	133
Seat Availability	111	109	225	78	20
Reliability	78	155	173	67	70
Staff Behaviour	55	105	167	87	129
Speed	77	83	197	113	73
Internal Asthetic	55	63	115	214	96
Entry & Exit	104	167	125	83	64

Fig. 1 and Fig. 2 show the Membership function plot for frequency and fare respectively after putting the value of attributes frequency and fare obtained from the commuter's survey.

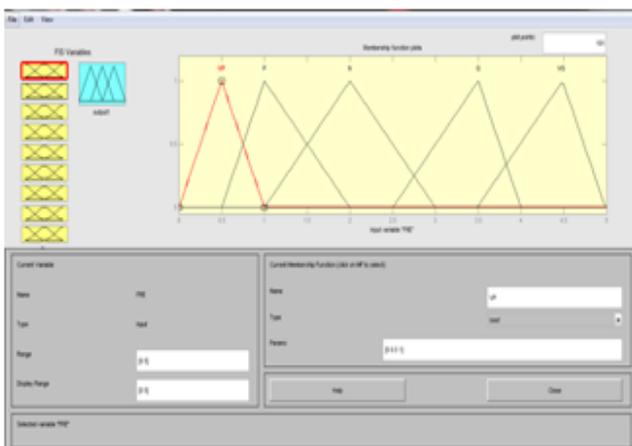


Fig.1. Membership function for Frequency

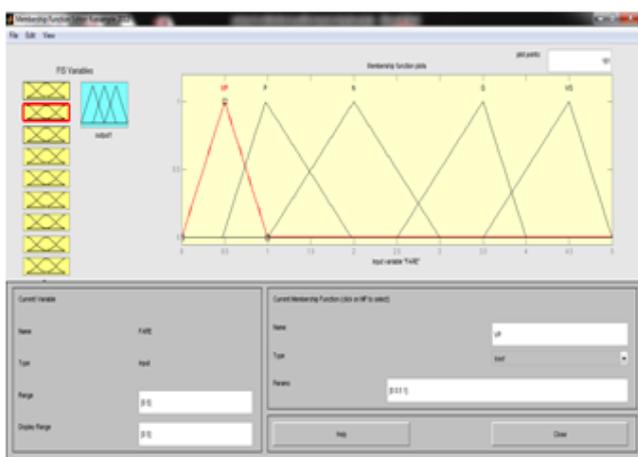


Fig.2. Membership function for Fare

Similarly Membership function plot for safety after putting the attribute value of safety obtained from the survey is shown in fig.3 and fig.4 shows the output plot for different-different membership functions.

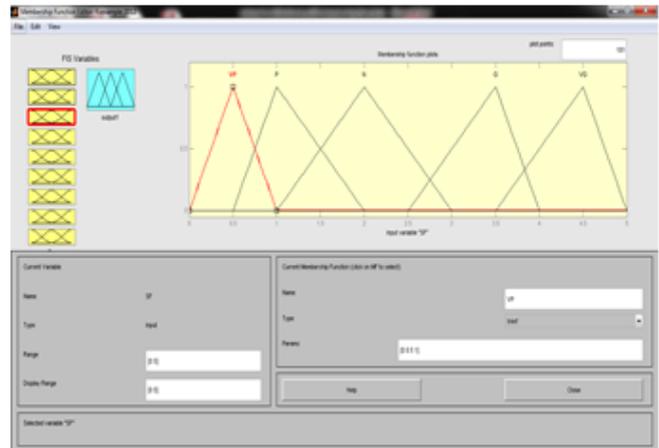


Fig.3. Membership function for Safety

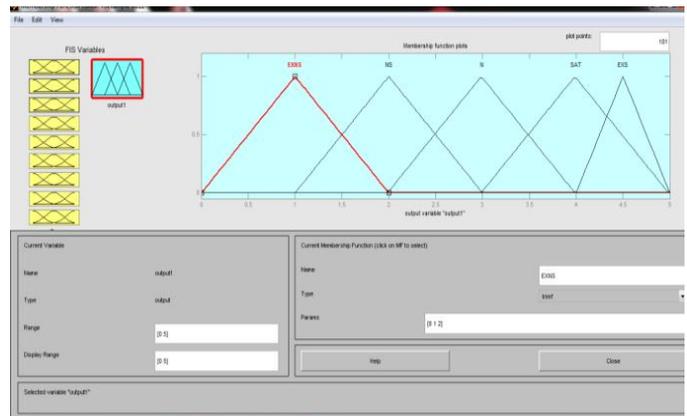


Fig.4. Membership function for Output

Fig.5. Shows the Graphical construction of the inference mechanism of fuzzy set

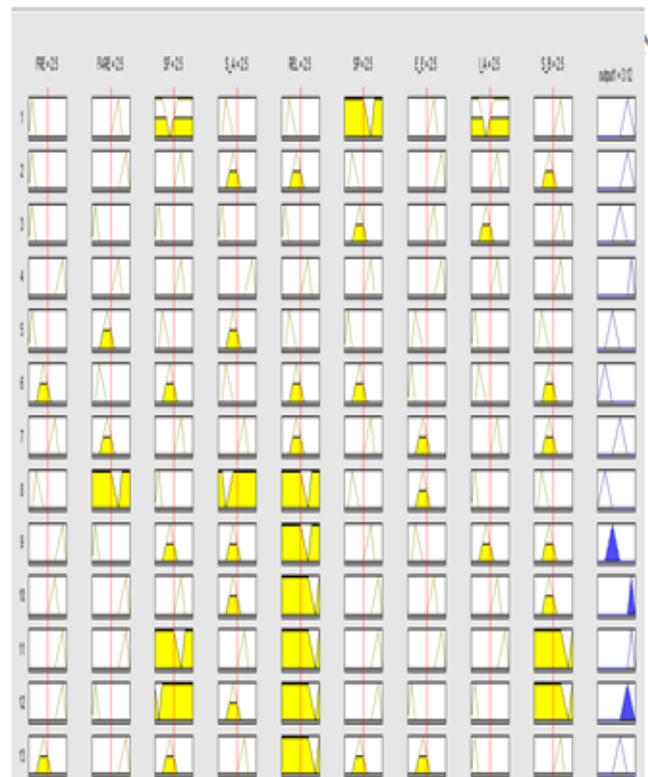


Fig.5. Graphical Construction of the Inference Mechanism of Fuzzy Set

## V. RESULTS & DISCUSSION

Study results shows that users are most satisfied with the speed, ease of payment, and journey travel time. The costs of present transit services are relatively cheap, and payment mode is also considered easy. Most of public transit systems in Bhopal city are mixed with other traffic, i.e. no form of right-of-way or preferential treatment available for public transit systems. Therefore, the interesting attribute of journey time could be explained by the fewer stops that these vehicles make. Though the overall customers satisfaction of most of the categories of services, by both the approaches are above the acceptance level of 0.5, there are some attributes with deficient service quality in each category of service gives warning for the immediate improvement in the existing services. Hence by improving the service quality of other attributes, there is sufficient scope for further improvement of overall customer's satisfaction. Therefore, it is necessary to increase user satisfaction through improving the public transit system in Bhopal. These improvements will make the city more sustainable and reduce the use of personalize modes in the future. High quality transit services will maintain existing users and attract new passengers. Also public transit system enhancements will lead to resolving problems like congestion, accidents, noise and air pollution, fuel consumption and other various problems associated with traffic and transportation.

## VI. CONCLUSION

This paper proposed a rule based approach to determine the satisfaction of customer in public transit using fuzzy logic. Use of fuzzy logic technique is materializing as rising trend in the industry. It is important to make evident the great potential that fuzzy logic has to offer, such as an effective mean for managing customer relationships. Fuzzy logic can be useful in resolving the conflicts by collaboration, propagation and aggregation and it also perform mimic humanlike reasoning. In this way, the system can learn the control parameters to take. By providing accurate information about the control elements, it allows service providers to drive the customer satisfaction, and get the potentially good benefit. With the help of linguistic variables and terms, the fuzzy logic approach also enables an intuitive querying process based on the terminology of the marketing department. All those tools help companies to maximize the value of their customers and, this way, their profits.

## VII. OUTCOME OF THE WORK

The present study identifies, describes, and measures the satisfaction level of public transit users. The most important implication of this work is the identification of the overall level of satisfaction of transit users. These findings of this work allow decision makers and responsible bodies to direct their efforts for the improvement of the level of services in the transit system. Also, it may be useful to personalized vehicle users, to find out their needs and preferences, and explore the potentials for a modal shift towards public transit. Although this study is specific to Bhopal city, its results could be applicable and beneficial to other developing cities which share the same traffic and transportation conditions. Also, it

may be useful to perform similar research in other developing countries like India for comparison purposes.

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